Original Research Paper

Mechanical Control of *Heliothis virescens* and *Pseudomonas syringae* in Tobacco Cultivation in Bengawan Solo

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Abstract: This study aims to evaluate the effectiveness of controlling Heliothis virescens infestation and Pseudomonas syringae Infection using synthetic pesticides on Nicotiana tabacum cultivation In Bengawan Solo, East Java, Indonesia. Results showed a decrease In pest density (from 6.8 to 3.7 individuals per plant), disease Intensity (from 52.0% to 30.7%), and leaf damage (from 48.5% to 26.4%). Furthermore, statistical analysis revealed significant differences between treatments ($p < 0.05$). Mechanical control significantly reduced the Incidence of pests and diseases In tobacco cultivation, with suppression efficiencies reaching 46.5% and 41.0%, respectively . In conclusion, farmer-led mechanical control Is an effective, low-cost, and sustainable strategy for managing pests and diseases In tobacco cultivation under tropical agroecological conditions, with potential to reduce dependence on synthetic pesticides and support environmentally friendly agricultural practices.

Keywords: *Heliothis virescens*; Mechanical control; *Pseudomonas syringae*; Sustainable agriculture; Tobacco cultivation.

Introduction

Nicotiana tabacum is an economically important plantation crop widely cultivated in Indonesia, particularly in East Java, where tropical environmental conditions support tobacco production throughout the growing season. Tobacco productivity and leaf quality are strongly influenced by agroecological factors such as temperature, rainfall, humidity, and soil fertility. These environmental variables also affect agroecosystem stability and determine the susceptibility of plants to pest infestation and disease infection. Under tropical conditions, high humidity and fluctuating climatic factors may accelerate the development of plant pathogens and insect pests, thereby reducing crop productivity and economic value. Therefore, environmentally adaptive cultivation and crop protection strategies are essential to maintain sustainable tobacco production systems (Rahman et al., 2022; Nugroho et al., 2022; *Manilkara: Journal of Bioscience*, 2023).

One of the major biological constraints in tobacco cultivation is infestation by *Heliothis virescens* and infection by *Pseudomonas syringae*. *H. Virescens* larvae attack young leaves and shoots, causing severe tissue damage that reduces photosynthetic activity and leaf quality. Meanwhile, *P. Syringae* infection induces necrosis, chlorosis, and physiological disturbances that negatively affect plant growth and production stability. These biological disturbances may significantly reduce the commercial quality and market value of tobacco leaves. Consequently, effective and environmentally sustainable pest and disease management practices are required to minimize production losses and improve cultivation stability under tropical conditions (Wijayanti et al., 2023; Tomaszewska-Sowa et al., 2022; Sari et al., 2021).

Currently, tobacco pest and disease management still relies heavily on synthetic pesticides because of their rapid suppression effects and practical field application. However, excessive and long-term chemical use may lead to pest resistance, environmental contamination, disruption of non-target organisms, and health risks for farmers. Such conditions indicate that chemical-based control alone is insufficient to support long-term agricultural sustainability in tropical agroecosystems. As an alternative approach, farmer-led mechanical control involving manual larval removal, field sanitation, pruning of infected tissues, and elimination of inoculum sources is considered more environmentally friendly and economically feasible. This method is also suitable for smallholder farming systems because it minimizes chemical residues while maintaining ecological balance under field conditions (Prasetyo et al., 2020; Kurniawan et al., 2022; *Manilkara: Journal of Bioscience*, 2024; Khairani et al., 2023).

Previous studies have primarily focused on synthetic pesticides, biological control agents, and integrated pest management strategies, whereas field-based evaluations of farmer-led mechanical control in the Bengawan Solo region remain limited. Studies simultaneously analyzing pest population dynamics, disease intensity, leaf damage, and agroecological conditions under non-pesticide management are still rarely reported. This limitation highlights the urgency of developing scientific evidence regarding the effectiveness of sustainable mechanical control practices in tropical tobacco cultivation systems. In addition, limited studies have evaluated mechanical control under real tropical farming conditions involving direct farmer participation and field-scale agroecological observations. Therefore, this study provides a field-based agroecological evaluation of farmer-led mechanical control without synthetic pesticides in tobacco cultivation in Bengawan Solo, East Java, Indonesia. This research aims to evaluate the effectiveness of mechanical control in suppressing *H. Virescens* infestation, reducing *P. Syringae* infection intensity, and improving tobacco cultivation conditions under tropical agroecological environments.

Materials and Methods

Study Area and Research Period

This study was conducted from February to March 2026 in three tobacco cultivation areas within the Bengawan Solo region, East Java, Indonesia, namely Plot A (downstream area), Plot B (upstream area), and Plot C (midstream area). These observation sites were selected to represent different agroecological characteristics in order to obtain a more comprehensive evaluation of farmer-based mechanical control under varying environmental conditions.

Table 1. Study Area Locations and Environmental Characteristics

No	Observation Location	GPS Coordinates	Elevation (m asl)	Soil Type	Environmental Conditions
1	Plot A – Downstream Area	7°01’09.5” S; 112°13’42.2” E	±15	Alluvial Clay	High humidity and river irrigation system
2	Plot B – Upstream Area	7°52’30” S; 111°31’45” E	±240	Reddish-Brown Latosol	Hilly terrain, good drainage, moderate to high humidity
3	Plot C – Mindstream Area	7°09’38.8” S; 111°52’04.2” E	±24	Alluvial Clay–Grumosol	Lowland area, moderate drainage, influenced by river flow

Plot A was located at 7°01′09.5″ S; 112°13′42.2″ E with an elevation of approximately ±15 m above sea level and was characterized by alluvial clay soil, high humidity, and river-based irrigation systems. Plot B was situated at 7°52′30″ S; 111°31′45″ E with an elevation of approximately ±240 m above sea level and exhibited reddish-brown latosol soil, hilly topography, good drainage conditions, and moderate to high humidity levels. Meanwhile, Plot C was located at 7°09′38.8″ S; 111°52′04.2″ E with an elevation of approximately ±24 m above sea level and was characterized by alluvial–grumosol soil, lowland topography, moderate drainage conditions, and strong influence from river flow.

The three study sites exhibited tropical agroclimatic conditions with air temperatures ranging from 27–32°C, relative humidity of 70–85%, and moderate rainfall intensity. These environmental conditions supported tobacco cultivation while simultaneously favoring the development of *Heliothis virescens* infestations and *Pseudomonas syringae* infections. Therefore, the selected locations were considered suitable for evaluating the effectiveness of mechanical control under different environmental conditions.

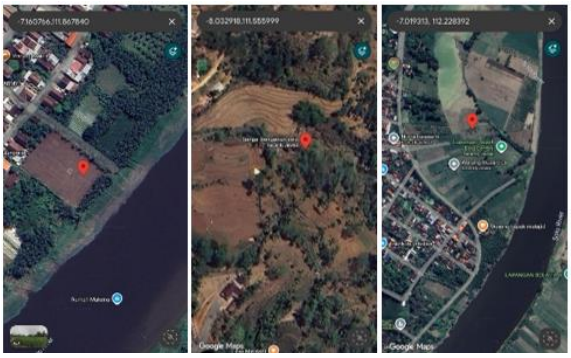

Plot A ***plot B*** ***plot C***

Figure 1. Geographic locations of tobacco cultivation plots in the Bengawan Solo region, East Java, Indonesia, consisting of downstream (Plot A), upstream (Plot B), and midstream (Plot C) observation areas.

Research Design

This study employed a field experimental approach using a Randomized Complete Block Design (RCBD) to evaluate the effectiveness of farmer-led mechanical control in suppressing *Heliothis virescens* infestation and *Pseudomonas syringae* infection in *Nicotiana tabacum* cultivation. The RCBD method was selected because environmental conditions in field experiments, such as soil fertility, humidity, and light intensity, were relatively heterogeneous and required block grouping to minimize experimental error and improve treatment validity.

The experimental design followed standard agricultural field experimental procedures described by Gomez and Gomez (2020). Two treatments were applied, namely: (1) control treatment without pest and disease management intervention and (2) farmer-led mechanical control without synthetic pesticide application. Each treatment was replicated three times, resulting in six experimental plots with relatively homogeneous environmental characteristics within each block. Each experimental plot measured 5 × 5 m and contained 50 tobacco plants.

Population, Sample, Variables, and Research Instruments

The research population consisted of all tobacco plants cultivated within the experimental area in the Bengawan Solo region. Sample plants were selected using a simple random sampling technique adapted from standard agricultural sampling procedures (Montgomery, 2021). The sampled tobacco plants were relatively homogeneous in terms of plant age, vegetative growth phase, cultivation management, and initial field conditions. Tobacco plants used in this study were approximately 5–6 weeks old during the initial observation period and showed relatively uniform vegetative development.

A total of 50 plants were randomly selected from each experimental plot as observation samples. The independent variable in this study was farmer-led mechanical control treatment, whereas the dependent variables included pest population density, disease intensity, leaf damage severity, and plant growth performance. Environmental parameters such as air temperature, relative humidity, soil pH, rainfall, and light intensity were treated as control variables. Data collection was conducted through direct field observations using structured observation sheets. The instruments and materials used in this study included thermometers, hygrometers, soil pH meters, light meters, measuring tapes, digital cameras, pruning scissors, gloves, field notebooks, ash or fine soil materials, and observation forms.

Mechanical Control Procedure

Mechanical control treatments were implemented based on agroecological practices commonly applied by local tobacco farmers. Prior to treatment application, field sanitation and initial land preparation were conducted to ensure relatively uniform plot conditions before experimental observations began. Mechanical control activities were carried out routinely throughout the eight-week observation period with weekly monitoring intervals. The applied control measures included manual removal of *H. virescens* larvae from leaves and plant shoots, pruning of leaves showing necrotic or chlorotic symptoms caused by *P. syringae*, removal of weeds and diseased plant debris, and elimination of potential inoculum sources within the cultivation area. Fine ash or soil dust was also applied to plant surfaces susceptible to pest attack as a physical barrier against larval feeding activity. This mechanical control approach was intended to reduce pest populations through physical disturbance while simultaneously minimizing pathogen inoculum sources under tropical field conditions.

Observation Parameters and Data Collection

Observations were conducted weekly for eight consecutive weeks across all treatment and control plots. Pest population density was determined based on the number of *H. virescens* individuals observed per sampled plant. Disease intensity caused by *P. syringae* was assessed based on the percentage of plants exhibiting necrotic lesions, chlorosis, and bacterial infection symptoms. Leaf damage severity was evaluated using a quantitative scoring system based on the percentage of damaged leaf area, where score 0 = no visible damage, score 1 = 1–25% leaf damage, score 2 = 26–50% damage, score 3 = 51–75% damage, and score 4 = >75% damage.

Plant growth parameters included plant height (cm) and number of leaves per plant as indicators of vegetative development. Environmental observations included air temperature, relative humidity, soil pH, rainfall intensity, and light intensity to evaluate the influence of microclimatic conditions on pest and disease development. All observation data were systematically recorded using standardized field observation sheets during direct field assessments.

Data Analysis

Research data were analyzed quantitatively using descriptive and inferential statistical approaches. Descriptive analysis was used to calculate mean values and percentage changes in pest population density, disease intensity, leaf damage severity, and plant growth parameters after treatment application. Inferential statistical analysis was performed using Analysis of Variance (ANOVA) at a 5% significance level ($p < 0.05$) to determine significant differences between treatments. Statistical analysis was conducted using *IBM SPSS Statistics* version 26.0.

The effectiveness of mechanical control treatments was calculated using the following equation:

$$\text{Effectiveness (\%)} = [(B - A) / B] \times 100$$

Keterangan:
- B = value before treatment
- A = value after treatment

The effectiveness criteria were interpreted based on the percentage reduction in pest population density, disease intensity, and leaf damage severity after treatment application. Higher percentage values indicated greater effectiveness of farmer-led mechanical control under tropical agroecological field conditions.

Results and discussion

Research Finding I. Effect of Mechanical Control on *Heliothis virescens* Population

Introductory Description

The results showed that farmer-based mechanical control reduced *Heliothis virescens* populations in all experimental plots during the observation period. The highest pest population before treatment was recorded in Plot B with 7.2 individuals per plant, while the lowest population after treatment was observed in Plot C with 3.2 individuals per plant. The most notable finding was the consistent reduction of pest density across all plots, with effectiveness values ranging from 43.1% to 50.8%, indicating that routine mechanical interventions contributed substantially to pest suppression under field conditions.

Research Findings

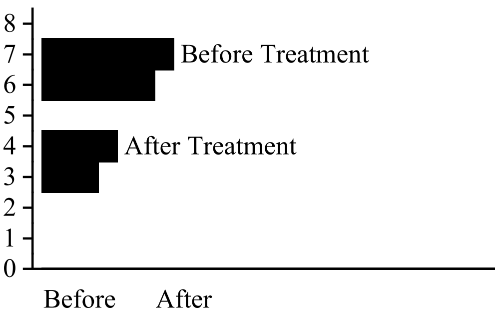
Table 1. Population Dynamics of ***Heliothis virescens*** Before and After Mechanical Control

Plot	Before Treatment (individuals/ plant)	After Treatment (individuals/ plant)	Reduction Effectiveness (%)
	6.8	3.7	45.6
Plot B	7.2	4.1	43.1
Plot C	6.5	3.2	50.8
Average	6.8	3.7	46.5

Source: Field observation data, 2026.

Graphical Presentation

Heliothis virescens Population Before and After Mechanical Control



Source: Processed field data, 2026.

Discussion

The findings demonstrate that farmer-based mechanical control significantly reduced *Heliothis virescens* populations in tobacco cultivation areas of the Bengawan Solo region. The average pest population declined from 6.8 individuals per plant before treatment to 3.7 individuals per plant after treatment, with an average suppression effectiveness of 46.5%. These results indicate that direct physical interventions, including manual larval removal and field sanitation, effectively interrupted pest population development during the cultivation period.

The reduction in pest density can be explained through ecological and biological mechanisms associated with mechanical control practices. Manual larval removal directly disrupted the larval phase of *H. virescens*, which represents the most destructive stage in tobacco plants because larvae actively consume young leaves and shoots. Field sanitation also reduced the availability of shelters and breeding sites, thereby limiting pest survival and reproduction. According to agroecological pest management theory, routine physical disturbance can suppress pest population growth by reducing reproductive success and weakening infestation continuity under field conditions.

These findings are consistent with previous studies reporting that mechanical control can effectively reduce pest infestation in tropical agricultural systems without relying on synthetic pesticides. Recent studies by Anwar et al. (2020) and Khairani et al. (2023) showed that manual pest removal and sanitation practices significantly decreased pest abundance and crop damage in smallholder farming systems. However, the present study demonstrated relatively higher effectiveness under field conditions in Bengawan Solo, likely because the interventions were conducted consistently throughout the observation period. Despite these positive findings, pest populations were not completely eliminated, indicating that environmental factors and pest migration from surrounding areas may still influence infestation levels.

From an applied perspective, the results indicate that farmer-led mechanical control has strong potential as a sustainable pest management strategy in tropical tobacco cultivation. The reduction of pest populations without synthetic pesticide application suggests that this approach may support environmentally friendly agricultural systems, reduce chemical residues, and minimize ecological disturbances in agroecosystems.

Research Finding II. Effect of Mechanical Control on Disease Intensity and Leaf Damage

Introductory Description

The results indicated that mechanical control practices substantially reduced *Pseudomonas syringae* infection intensity and leaf damage severity in tobacco plants. The highest disease intensity was observed before treatment, reaching 52.0%, whereas the lowest disease intensity after treatment was recorded in Plot C at 26.0%. In addition, leaf damage declined considerably from 48.5% before treatment to 26.4% after treatment, indicating that sanitation and pruning practices contributed to improved plant health under tropical field conditions.

Research Findings

Table 2. Disease Intensity of ***Pseudomonas syringae*** in Tobacco Plants

Plot	Number of Plants Observed	Infected Plants	Disease Intensity (%)	Disease Category
Plot A	50	18	36.0	Moderate
Plot B	50	15	30.0	Low–Moderate
Plot C	50	13	26.0	Low

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Average	150	46	30.7	Moderately Reduced

Source: Field observation data, 2026.

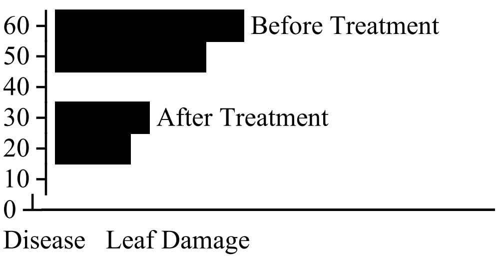
Table 3. Leaf Damage Severity Before and After Mechanical Control

Parameter	Before Treatment (%)	After Treatment (%)	Reduction Effectiveness (%)
Leaf Damage Severity	48.5	26.4	45.6

Source: Field observation data, 2026.

Graphical Presentation

Disease Intensity and Leaf Damage Reduction



Source: Processed field data, 2026.

Discussion

The results demonstrate that farmer-based mechanical control effectively reduced disease intensity caused by *Pseudomonas syringae* in tobacco plants. Disease intensity declined from 52.0% before treatment to 30.7% after treatment, while leaf damage severity decreased from 48.5% to 26.4%. These findings indicate that sanitation practices, removal of infected tissues, and pruning of symptomatic leaves successfully reduced pathogen spread and minimized tissue damage during the cultivation period.

The effectiveness of mechanical control was strongly associated with reductions in inoculum sources within the cultivation environment. Pruning of infected tissues removed bacterial infection sites, whereas field sanitation reduced organic debris that could support pathogen survival under humid tropical conditions. According to plant pathology principles, decreasing inoculum density can significantly suppress disease transmission rates and reduce secondary infection cycles. Lower disease pressure consequently improved photosynthetic efficiency and supported more stable vegetative growth in tobacco plants.

The present findings are in agreement with previous studies emphasizing the importance of sanitation-based disease management in tropical agricultural systems. Wijayanti *et al.,* (2023) reported that routine pruning and removal of infected plant materials reduced bacterial disease incidence in tobacco cultivation. Similarly, Tomaszewska-Sowa *et al.*, (2022) found that minimizing infected tissue exposure effectively restricted bacterial spread under humid environmental conditions. Nevertheless, disease symptoms remained present in several plots, indicating that environmental humidity and field microclimate still favored pathogen persistence despite the applied control measures. The practical implication of these findings is that mechanical disease management can serve as an environmentally safe alternative to intensive synthetic pesticide use in tobacco cultivation. The observed reduction in disease intensity and leaf damage suggests that sustainable field sanitation practices may improve crop productivity while maintaining ecological balance within tropical agroecosystems.

Research Finding III. Environmental Conditions Supporting Pest and Disease Development

Introductory Description

Environmental observations revealed that microclimatic conditions varied among the experimental plots and influenced pest and disease development during the study period. The highest relative humidity was recorded in Plot A at 81%, whereas the highest light intensity occurred in Plot C at 6,120 lux. These environmental variations were considered important because humid conditions tended to favor pathogen development, while adequate light intensity supported plant recovery and vegetative growth after treatment application.

Research Findings

Table 4. Environmental Parameters During the Study Period

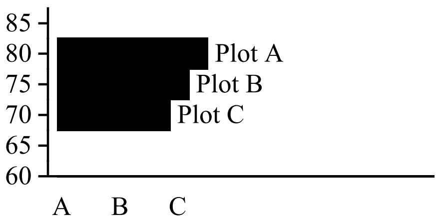
Plot	Air Temperature (°C)	Relative Humidity (%)	Soil pH	Light Intensity (lux)	Rainfall (mm/week)

Plot A	28.4	81	6.2	5,200	42
Plot B	29.1	78	6.5	5,850	38
Plot C	30.0	75	6.4	6,120	35

Source: Field observation data, 2026.

Graphical Presentation

Relative Humidity Across Experimental Plots



Source: Processed field data, 2026.

Discussion

Environmental conditions during the study period played an important role in influencing the effectiveness of mechanical control treatments. Relative humidity ranged from 75% to 81%, while air temperature ranged from 28.4°C to 30.0°C. These environmental conditions generally supported both tobacco growth and the development of pests and pathogens under tropical agroecological conditions.

High humidity particularly favored the survival and spread of *Pseudomonas syringae* because bacterial pathogens generally proliferate more rapidly under moist environmental conditions. In contrast, adequate light intensity contributed positively to plant recovery processes by supporting photosynthetic activity and vegetative growth following mechanical treatment. Near-neutral soil pH values also created suitable conditions for tobacco development, although such conditions may simultaneously support pest persistence.

These findings are consistent with agroecological studies showing that microclimatic conditions strongly influence pest population dynamics and pathogen transmission in tropical cropping systems. Hidayat et al. (2024) reported that elevated humidity levels significantly increased bacterial disease development in tobacco fields, whereas stable environmental conditions improved plant physiological resilience. However, the present study specifically demonstrates that environmental management combined with mechanical control may improve suppression effectiveness under field conditions. The results suggest that successful implementation of mechanical control strategies should be integrated with environmental management approaches to reduce humidity-related disease risks and improve crop resilience. This integration may strengthen sustainable pest and disease management systems in tropical tobacco cultivation.

Research Finding IV. Mechanisms and Sustainability of Farmer-Based Mechanical Control

Introductory Description

The implementation of farmer-based mechanical control involved several integrated physical interventions designed to suppress pest populations and reduce pathogen inoculum sources in tobacco cultivation. The most frequently applied control measures included manual larval removal, field sanitation, and pruning of infected leaves. These practices were conducted routinely throughout the cultivation period and contributed to measurable reductions in pest infestation and disease intensity under field conditions.

Research Findings

Table 5. Farmer-Based Mechanical Control Practices Applied During the Study

No.	Mechanical Control Practice	Description of Activity	Frequency	Main Objective
1	Larval Removal	Manual collection of larvae from leaves and shoots	2–3 times/week	Reduce pest population
2	Field Sanitation	Removal of weeds and plant debris	Weekly	Reduce pathogen sources
3	Leaf Pruning	Removal of symptomatic leaves	As needed	Prevent disease spread

4	Removal of Infected Plants	Elimination of severely infected plants	Incidental	Eliminate inoculum

Source: Field observation data, 2026.

Graphical Presentation

Frequency of Mechanical Control Activities

Source: Processed field data, 2026.

Discussion

The results demonstrated that farmer-led mechanical management effectively reduced pest infestation and suppressed pathogen development in tobacco cultivation under tropical agroecological conditions. The reduction in *Heliothis virescens* population density indicated that direct physical intervention successfully disrupted pest development during the larval stage, which represents the most destructive phase in tobacco plants. Simultaneously, sanitation practices and pruning of infected tissues reduced the persistence and transmission of *Pseudomonas syringae* within the cultivation environment. These findings confirm that non-chemical field management contributed substantially to lowering biotic stress throughout the cultivation period.

The effectiveness of the applied management practices was strongly associated with ecological mechanisms involving habitat disturbance and inoculum reduction. Routine field sanitation decreased the accumulation of weeds, fallen leaves, and organic debris that potentially functioned as shelters for pests and reservoirs for bacterial pathogens. In addition, pruning of symptomatic leaves improved canopy aeration and reduced excessive humidity around plant tissues, thereby limiting environmental conditions favorable for bacterial proliferation. Reduced pest and disease pressure consequently preserved leaf photosynthetic activity, minimized tissue damage, and supported more stable vegetative growth in tobacco plants during the observation period.

The present findings are consistent with agroecological theories emphasizing that environmentally based crop protection strategies can effectively suppress pest and pathogen pressure while maintaining ecosystem stability. Khairani et al. (2023) reported that routine sanitation and manual pest removal significantly reduced insect infestation intensity in tropical smallholder agricultural systems. Similarly, Faturrahman et al. (2024) demonstrated that sanitation-based disease management effectively lowered bacterial infection rates and reduced ecological risks associated with excessive synthetic pesticide application. In comparison with chemical-based approaches, the management strategy applied in the present study showed stronger compatibility with sustainable agricultural principles because it minimized environmental contamination and reduced the potential accumulation of pesticide residues within cultivation areas.

Although the applied mechanical management demonstrated considerable effectiveness, several limitations should still be acknowledged. The implementation of continuous physical intervention requires substantial labor availability and regular field monitoring to maintain suppression effectiveness throughout the cultivation cycle. Moreover, environmental variability, particularly high humidity and pest migration from surrounding cultivation areas, may influence long-term control stability under open-field conditions. Nevertheless, the substantial reduction in pest populations, disease intensity, and leaf damage observed in this study indicates that farmer-led mechanical management possesses strong potential as a low-cost, environmentally sustainable, and practically applicable strategy for tobacco cultivation management in the Bengawan Solo region under tropical agroecological conditions.

Conclusion

The present study demonstrated that farmer-led mechanical management effectively reduced *Heliothis virescens* population density, suppressed *Pseudomonas syringae* disease intensity, and decreased leaf damage severity in tobacco cultivation under tropical agroecological conditions in the Bengawan Solo region. Routine physical interventions, including manual larval removal, field sanitation, and pruning of infected tissues, contributed significantly to reducing biotic stress and improving plant physiological stability throughout the cultivation period. The findings further indicate that sanitation-based non-chemical management possesses strong potential as a low-cost and environmentally sustainable strategy for pest and disease control in smallholder tobacco farming systems. Nevertheless, environmental variability and continuous labor requirements remain important factors influencing the long-term effectiveness of mechanical management under open-field cultivation conditions.

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